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Studies of Dynamic Properties of Shock Compressed Solids by in-situ Transient X-Ray Diffraction

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In the transient diffraction NLYF proposal we set forward a program of work to investigate the response of crystals to shock compression in regions of strain rates previously unexplored, in a coordinated experimental, computational, and analytical program. Time resolved x-ray diffraction was used to directly determine the lattice parameters of crystals during shock loading previously on the Nova and Trident laser facilities. Under this proposal we extended this work to exploit the multi-beam direct drive capability of the Omega laser facility to allow more extensive diagnostic access for measuring the lattice parameters both parallel and perpendicular to the shock front.

Under the NLUF Program in FY 99, we transitioned the dynamic diffraction experiments to the OMEGA facility. We developed a direct drive target configuration that uses a single beam to direct irradiate the surface of a thin crystal and 4 beams to irradiate a separate metal backlighter foil. Experiments were done with single crystal Si to demonstrate that the target design worked and that simultaneous measurements of compression both parallel and perpendicular to the shock propagation direction could be performed. We obtained simultaneous measurements of the (400) and (040) lattice planes during the period when a shock traveled through the crystal in the (100) direction. Follow-up experiments were done to demonstrate that this technique would work with thin metal crystals such as Cu. Simultaneous measurements were made of the (200) and (020) lattice planes of Cu shocked along the (100) direction.

Future experiments (FY 00 and beyond) will be focussed on further studying the time resolved lattice response in Cu at a range of shock pressures. Additional techniques such as introducing a knife edge near the x-ray source are expected to provide information about the density of lattice dislocations created by the shock front. Results from these experiments will enable the separation of elastic and plastic components of strain in directions both parallel and perpendicular to the front at the strain rates of 10^6-10^{10} s^{-1}. Current constitutive equations are highly speculative in this strain rate region. Time resolved measurements of lattice spacing at the shock front will establish plastic deformation rates independent of any model assumptions.

During FY 99, we performed a total of 24 laser experiments to demonstrate this technique on OMEGA and resolve diagnostic and timing issues.

The results from this work were presented at three conferences and several seminar presentations, and will also be described in future conference presentations.

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